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ORIGINAL ARTICLE

Situated design of line-oriented flight training (LOFT): a case study in a Brazilian airline

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Abstract This paper describes an exploratory situated approach for the design, development, standardization, and implementation of line-oriented flight training (LOFT) in a major airline. LOFT was conceived in aviation industry to be a practical application of crew resource management (CRM) concepts. The situated approach combines a set of methods and techniques from ergonomics and human factors disciplines. These methods were supported by social construction enabling the involvement and participation of different actors of the operational, tactical, and strategic level of the company. Under this framework, situated design is progressively established by socially constructed patterns up to a situated design comprising the construction of scenarios, training tools, procedures, structures, organization, flight documents, operations, and further training management contents. Our findings indicate that LOFT situated design, framed by social construction, can be applied to any aviation system with a specific culture and organization, which may be different from the ones that were implicitly or explicitly taken into account during the development of general LOFT guidelines.

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1 Introduction

Worldwide statistics on aviation accidents show that in the beginning of the 1960s, about seventy accidents out of millions of takeoffs had occurred in the commercial aviation industry. Due to technical improvements of airplanes, associated with more intense technical training for pilots and flight engineers, this number was reduced to less than ten accidents out of millions of takeoffs in the beginning of the 1970s. Worldwide air transportation activity has been intensified, causing an increase in the number of takeoffs. Yet despite the decrease in accident percentages, the absolute number of accidents continues to rise.

During the mid-1970s and into the 1980s, the FAA, NASA, US Air Force, and other educational institutions conducted studies on the effects of flight on the human body (Flight Physiology), as well as the traditional roles of crewmembers in normal and abnormal flights. This research also focused on the interactions between various crewmembers in different phases of flight. In addition to laboratory studies, researchers also collected data from various aviation accidents that had occurred during this time period, like the United Airlines Flight 173 accident occurred in 1987. Research based on these data indicated that a safe flight is the outcome of an effective error management by the crews (McFadden and Towell 1999). Researchers also concluded that data indicated a lack of training in crew management (crew coordination), leadership, teamwork, and other aspects not directly related to piloting technique (Helmreich 2000). CAA (2002) report stated that "it has long been known that some three out of four accidents result from less than optimum human performance and this indicates that any advance in this field will have a significant impact on the improvement of flight safety" (CAA 2002). These new interpretation regarding the contributing factors of accidents resulted in the formulation of a group of concepts that would be used to manage crew activity and in the development of a new tool denominated Crew Resource Management—CRM (Helmreich et al. 1999).

1.1 Crew resource management—CRM

In aviation industry, CRM means a certification requirement for flight safety delivered by international organizations such as the International Civil Aviation Organization (ICAO). In Brazil, the Civil Aviation Authority has already regulated CRM through the Civil Aviation Instruction IAC 060-1002 (DAC 2003). CRM training is recognized as one practical application of human factors, and it has some essential features (CAA 2002): "The training should focus on the functioning of the flight crew as an intact team, not simply as a collection of technically competent individuals; and should provide opportunities for crew members to practice their skills together in the roles they normally perform in flight. The program should teach crew members how to use their own personal and leadership styles in ways that foster crew effectiveness. The program should also teach crew members that their behavior during normal, routine circumstances can have a powerful impact on how well the crew as a whole functions during high-workload, stressful situations."

The principles of CRM, as described in the IAC-060 1002, are based on the effective management of a pilot's available resources (Blake et al. 1990; Seamster et al. 1998). CRM is a training philosophy that aims to adapt a pilot's effective behavior through the reinforcement of his or her ability to manage the entire set of available resources, technical resources, and those related to crewmember relationships. CRM concepts and training philosophy have been developed throughout the years in many steps, beginning with the concept of Cockpit Resource Management, then Crew Resource Management, and presently, Company Resource Management. Modern large-scale aviation organizations are still searching for solutions meant to enhance flight safety, manage organizational changes toward a better culture of safety, standardization of human resources management, and invest in training programs and training certifications (Holtbrügge et al. 2006).

1.2 Line-oriented flight training—LOFT

As a way to practice CRM concepts, the line-oriented flight training (LOFT) is a group performance training exercise to provide practice and feedback in crew coordination and CRM. LOFT scenarios should be designed to test the coordinated efforts of all crew members for successful crew performance. LOFT appears to be particularly effective when it is coupled with adequate debriefing techniques and supports such a videotape feedback and self-critique (CAA 2002).

LOFT provides a way to train for *normal situations*—not in the sense of desired or expected situations, but those that can occur during the flight—and allows pilots to better manage their flight resources, thus avoiding surprises. The LOFT design principles developed by ICAO allow crews the opportunity to self-analyze their behavior, through facilitators, considering the flight management resources available.

LOFT provides preventive and proactive training on flight safety, carried out as part of initial or recurrent flight crew training in a simulator. In LOFT procedure, a complete crew flies representative flight segments that may contain normal, abnormal, and emergency situations expected in line operations. An instructor monitors the crew's performance and reviews the simulated flight(s) with the crew afterward, to assess the effectiveness of each decision made, especially after the occurrence of unexpected situations. LOFT involves detailed, real-time, normal operational routines and procedures that represent flight operations of airline companies. The emphasis is on abnormal situations involving communications, management, and leadership, as well as other cognitive functions necessary to cope with these situations. To do so, the abnormalities included in the scenario simulation are not pre-briefed and therefore can be viewed as unexpected situations.

Many sources of information may be used to develop LOFT sceneries, such as accident reports. However, a more realistic and appropriate starting point is to develop a LOFT program based on the current airline's operations and culture for the following reasons (Helmreich and Foushee 2010):

(a) If similar errors or inadequate decisions appear to recur among pilots, this may signal a potentially error-forcing environment (EFE) and may indicate serious problems such as inadequate procedures, manuals that conflict or provide incorrect information, the lack of a safety culture, or other aspects related to operation/cognition;
(b) A LOFT program may uncover areas in aircrew training programs that are weak or require emphasis;
(c) A LOFT program may reveal problems with instrument locations, information presented to pilots, or difficulties with the physical layout of a particular flight deck;
(d) Air carriers can use it to test and verify flight deck operational procedures and the overall effectiveness of their training programs.

To be able to accomplish with these requirements, a LOFT program should not be used for checking individual performances. Instead, it shall be used for learning about resource management situations out of the scope of regular procedural checking. Therefore, LOFT sessions enhance learning opportunities that should be afforded for individuals and crews. A LOFT session should not be interrupted except in extreme and unusual circumstances. Repositioning of the simulator and repetition of problems are inconsistent with the principles of LOFT, as the aim of LOFT is to develop preparedness for resource management in different situations that may happen in normal flights.

Part of the benefit of LOFT comes from providing an individual or a crew the ability to quickly grasp the results (positive or negative) about decision-making and actions. This does not cope with interruptions. At the end of each scenario, a thorough debriefing should be conducted. Debrief session introduces some notable issues aiming at the assimilation process by the participants. Hence, debriefing should not be a rapid formalism, but a guided review of those notable issues. The dynamics begins with the crew self-debriefing, followed by the LOFT facilitator debriefing. Debriefing should include the use of available recorders, from nonlinear video recorders to written notes.

1.3 Aims and scope

The aim of this paper was to present an exploratory grounded/situated framework for LOFT design, describing the training conception, development, standardization, and implementation in a major airline company operating in Brazil. The scope includes the development of training scenarios, training tools, procedures, structures, organization, flight documents, facilitators' formation, training operation, and management. We also argue about the need of situated approach for designing a training program such as LOFT, using grounded and participatory methods instead of the implementation of a previously prepared training program. We believe that this paper can contribute to the debate about the design of training regarding the management of complex socio-technical systems by a crew or a collective and about how to implement general recommendations about the training in a specific organizational setting.

2 Methodological framework

The LOFT design framework took into account the company's culture, profile, and experiences of its pilots, instructors, and facilitators; the differences in design of technical systems of the aircrafts, even when they belonged to the same manufacturing technology, and the documents of each aircraft. For the LOFT situated design, it is important to consider elements and variables that describe the company and its actual operational context. This is done in a participatory way, where scenarios and training documentation should be designed according to the company culture, which depends on the personnel knowledge, experience, and about what these people consider as key elements to their training. This is done in addition to the recommended standards, technical literature, accident report recommendations, and so forth.

This required the use of a scientific methodology based on socio-technical/situated approaches (Darses and Falzon 1996). More precisely, we adopted a grounded approach configuring a situated design process. The situated design is based upon a strong participation in the entire design process, with the involvement of pilots, instructors, checkers, crews, and other stakeholders of flight safety. We emphasize, again, the grounded character of this process, which considered the analysis of the activities of the pilots in various training processes of the company.

People who participated in the training design process were involved with the collaboration of the company's human factors coordinator and training director. The company had a strategy for LOFT development because it was required to fly in the USA airspace. Therefore, the training director argued about the importance of the LOFT throughout the company, asking for the collaboration and commitment of everybody involved. The human factors coordinator, following the determination of the training director, mobilized the team managers, instructors, and pilots, through meetings, to assist the ergonomists in their requests and participate actively in the design and implementation of LOFT. The situated design resulted in the customization of the LOFT for the company based on the LOFT guidelines suggested by the ICAO standards.

The situated design began with the study of company's training and flight documentation such as CRM training sheets, flight check lists, minimum equipment list—MEL, basic air navigation procedures and chats, meteorological flight data, company basic flight schedules. It was followed by pilot's and instructor's activity analysis during training situations. To perform activity analysis, the ergonomic research team, composed by two experienced ergonomists, used ergonomics work analysis—EWA (Wisner 1995; Jatobá et al. 2016), conversational actions techniques (Vidal 1994; Vidal and Bonfatti 2003; Vidal et al. 2009), and systematic observation of training situations (Carvalho et al. 2012). The research was complemented by specific tools, like a dedicated questionnaire containing closed and open questions about social and professional characteristics of pilots, stakeholders, and potential facilitators of LOFT.

Figure 1 summarizes the methodological framework illustrating the relationship of competences needed for

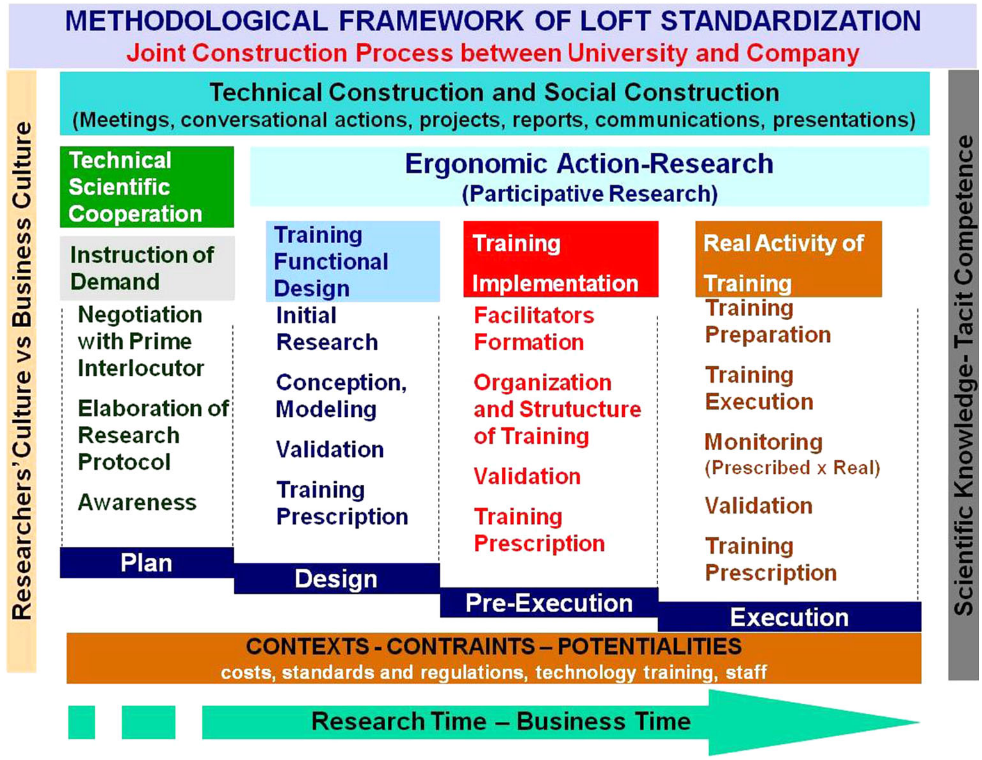

Fig. 1 Conceptual and methodological framework for LOFT situated standardization

situated design of the company's LOFT. It expresses the differences in cultures and knowledge, as well as the socio-technical driving forces for negotiations, ensuring the involvement of stakeholders in LOFT situated design amidst a continually changing work context.

Phase 1 concerned the technical–scientific cooperation process, which was built between the company and the researchers. It encompasses the definition of research scope (demand instruction) within the organization's tactical (executive staff: manager, engineer, section chief) and strategic (decision-making staff: director, vice president, president) levels. This phase required an explicit demand from management, enabling the dialogue with the decision-makers of the company for approval. The phase ended with a research agreement signed by the company and the university about the overall research development, which would result in the implementation of the LOFT program.

Phase 2, training functional design, began with the researchers participating in the ground-school course for pilots, seeking to acquire basic knowledge about the company, the aircrafts for which LOFT was being designed, and to become more familiar with aviation context. They also participated in initial CRM (course introduction) and CRM refreshment trainings of the company, analyzing pilots and instructor activities. This was very important to overcome the initial difficulties faced and to facilitate the development of interviews with subjects and their collaborations.

After that, there was a survey among those who potentially would become a LOFT facilitator. It was a study of the population. This survey aimed to gather information on the needs of the training; identify the socio-professional profile of the staff; establish the understanding they have on topics such as flight safety, CRM, and LOFT; experience in this area, their interest in becoming LOFT facilitators, the need for training to be a facilitator of LOFT; and also to gather suggestions about the types of scenarios, frequency, duration, among others, that should compose a training of this nature.

The LOFT design was then started considering the data gathering during the entire research process. These data were mainly composed by the scenarios and flight situations provided by potential facilitators and pilots. In these data, the culture and company values were embedded, including company procedures, standards, and guidelines used. Other data used were inputs from company's technical staff (schedule sector, flight engineer, dispatchers, mechanics, etc.), flight attendants, and information about the flight simulator characteristics and its technical possibilities from the staff of the simulator rental company.

Phase 3, LOFT implementation, began with LOFT facilitator's training. This training was developed as a company standardized training for preparation/training of LOFT facilitators. The participants of this training were the training instructors of the company, as previously defined by the training director, after consulting the human factors coordinator, the counselor–facilitator, and the researchers. The training includes theoretical issues and practical exercises. In the theoretical part, the CRM concepts were worked through discussions of incident and accident cases. These cases were selected from well-known worldwide aviation accidents including the company accidents related as much as possible to the practical part of the training. The theoretical part was important to familiarize the LOFT trainee facilitator with the new tools of the LOFT.

In the practical exercises, the facilitator in training conducted a comprehensive LOFT (briefing, LOFT flight in the simulator and debriefing), with two pilots in the cockpit, being supervised and guided by a facilitator–counselor. The facilitator–counselor was appointed by the human factors coordinator and supported by the company's training director. He was considered the most experienced pilot and instructor of the company. These practical exercises used the proposed LOFT design for the first time in the company. They were analyzed by the research team together with the training participants (trainee facilitators, pilots) and counselor–facilitator using conversational analysis, as way to reflect upon the first prototype of the LOFT. Based on the feedback provided by the participants and discussions with the counselor–facilitator, it was possible to make adjustments in the training structure including scenarios script and realism, improve training documentation and sheets, technological issues regarding the simulator, and so forth.

In the practical exercises, the facilitator in training conducts a comprehensive LOFT, being supervised and guided by a facilitator–counselor. The facilitator–counselor was appointed by the training director and supported by the company's training director. He was considered the most experienced pilot and instructor of the company. These practical exercises used the proposed LOFT design for the first time in the company. They were analyzed by the research team together with the training participants and instructors using conversational analysis, as way to reflect upon the first prototype of the LOFT. Based on the feedback provided by the participants and discussions with the counselor–facilitator, it was possible to made adjustments in the training structure including scenarios script and realism, improve training documentation and sheets, technological issues regarding the simulator, and so forth.

Phase 4, training activity, was about the final realization of the LOFT, including the preparation, application, and evaluation. During this phase, the research team follows several LOFT sections conducted by the facilitators approved in phase 3. After each section, they conducted meetings with the facilitator of the section, and a pair of trained pilots selected according to the training program of the company. The results of these meetings were used to make final adjustments and validate the overall process, allowing the emission of the final set of training procedures and documentation.

3 Loft situated design

Based on the methodological framework, the situated design of this LOFT required, in turn, a set of methodological stages. Table 1 summarizes these contents.

3.1 Global research

At the beginning of grounded actions, ergonomic researchers have to deal with issues that challenge their practice. These issues are related both to an inadequate understanding of the ergonomist actual role (as a non-expert in domain) by the subjects and to an inadequate understanding of the needs to accomplish a project by the managers (leading to simplified or preconceived solutions). That is why the ergonomic action unavoidably relies on a process of global research with a dual purpose: in one hand for the researches to achieve a better understanding of the company and of some features of its organizational culture. In other hand, ergonomists have to show to the stakeholders (training director, human factors coordinator, pilots, instructors) the need and importance of their work for the situated design, being able to discuss the design solutions with these stakeholders. The global research also shed some light about the design issues and problems whether preconceived solutions were used without discussion. It is also important to emphasize that situated constructed solutions are not in opposition or rejection of preconceived ones, it is just a truly way to construct novel (better) solutions through reflections about already existing material, with the participation of interested and committed people. It makes them more reliable and relevant because everyone is able to check for possible problems, conflicts and gaps, and correct or solve problems during the design process.

In this research, the training director of the Company initially decided that the pilots' instructors and checkers would be chosen as LOFT facilitators. Therefore, a global research was launched to investigate instructors and checkers. The procedure assembled a socio-professional study within instructors and checkers of the company, along with an analysis of reference situations—CRM training and Emergency training in simulator. The analysis of CRM training aimed to verify the content and the reliability of that training because CRM and LOFT contents should be integrated, according to the ICAO recommendations. The emergency training has been observed to check the operation of the simulator (the same that would be used for LOFT), analyzing the work of instructors and

Table 1 Set of methodological actions for LOFT situated design

Stages	Objectives	Brief descriptions
Global research	Socio-professional study	Application of a survey using the POPLOFT questionnaire
	CRM training observation	Observations of an initial CRM and CRM phase II trainings carried out ***in loco***
	Reference situation analysis: emergency training	Analysis of the training culture, the places/offices/resources available, and the functioning of the simulator
Focused research	Data definition (establishment of observables)	Information regarding training needs such as types of technical breakdowns and resource management issues that could be used in the LOFT scenarios, briefing and debriefing duration, dynamics, etc.
	Data collection: empirical registers for LOFT design	Gathering information regarding training needs defined by the researchers according to the director of training, human factors coordinator, facilitator–counselor, and based on ICAO recommendations for LOFT
Training development	Scenarios development	Scenarios based on data (technical breakdowns and management issues, the briefing/debriefing duration, etc.) collected during the former research phases
	Standard operating procedures (SOP) development	Operational and technical procedures to be used as guidelines for facilitators to conduct the LOFT
	LOFT test	Testing conducted in the CAE simulator-training facility. Complete LOFT sessions to test scenarios/simulator functioning compatibility, training structure, dynamics, etc.
	LOFT validation	Final participatory review of the training by the LOFT facilitators and pilots in training, director of training, human factors coordinator, facilitator–counselor, mediated by the researches
Facilitator training system	LOFT functioning	The theoretical part of the facilitator training system aimed to familiarize the LOFT trainee facilitator (facilitator in training) with the new tools of the LOFT. It comprises the CRM/LOFT concepts and issues, the operation of LOFT, the application of LOFT in the three phases (briefing, LOFT flight in the simulator, and debriefing), the role of the LOFT facilitator, the set of LOFT documentation to be used by the facilitators, and others
	Loft facilitation	The practical exercise, in which the facilitator in training conducts a comprehensive LOFT for three times, being supervised and guided by a facilitator–counselor. Behavior issues during briefing/debriefing sessions, special roles to play during LOFT sessions (non-technical crew member, air traffic controller, operational staff)

checkers, who would future LOFT facilitators, and to observe the behavior of the pilots of the aircraft, future users of LOFT in the company. In addition, this phase was supported by the company training department by means of written communication explaining the role of researchers and the research objectives, including a request for the collaboration of all people involved.

3.1.1 Social–professional study

Based on the results of a survey, we interviewed the training director and all instructors and checkers of the company: 13 simulator-training instructors and 7 simulator and route-training checkers.

The interviews revealed that the simulator and route-training checkers had more working time in the company than the instructors. Most checkers (86 %) had been with the company between 5 and 10 years, while 49 % of the instructors had been with the company for less than 1 year, and 74 % for a maximum of 4 years. The instructors were, almost entirely, retired pilots from other airlines hired to provide technical instruction.

These data indicated that checkers had greater influence on the company's culture than instructors, and also more working time in the company, two important characteristics to be a LOFT facilitator. This is an important finding of the situated research indicating that checkers, even if they are not included as possible LOFT facilitators, they might have important contributions for the training design.

It was also found that the instructors had more accumulated flying hours than checkers. The instructors' flight hours ranged from 12,000 to 20,000 h, with an average of 15,786 h, while the checkers ranged between 7000 and 17,400 h, totaling an average of 8986 h of accumulated flight hours. Only two instructors had flown the aircraft in which LOFT would be developed, totaling 700 and 1000 h, respectively. All checkers, in turn, flew the aircraft from 980 to 6100 h, an average of 4454 h. Among the instructors and checkers found, none had previously been LOFT facilitators for this company. Only two instructors were LOFT instructors at other companies. Only one checker was a LOFT instructor in another company for 2 years.

Although LOFT is a practical application of CRM concepts, it was found that only 25 % of instructors had participated in the CRM course during the last year, 37 % of instructors had not participated for more than 5 years, and 71 % of instructors had not taken any CRM courses in this company. Thirty-three percent of the checkers participated in the CRM course last year, and 67 % did not participate in any CRM courses within the last 5 years; 86 % of checkers participated in their last year of CRM within this company. Regarding LOFT, 87 % of instructors remained more than 1 year without receiving this training and 49 % for over 5 years. All checkers remained more than 1 year without receiving LOFT. Among these checkers, 57 % were between 3 and 5 years without LOFT and 43 % between 1 and 3 years. About 81 % of checkers and instructors interviewed recognized that the company should provide specific training for future professionals to compose a team of LOFT facilitators.

These data were used to define who should be trained as LOFT facilitator. Initially, the training director considered that instructors and checkers should be prepared as LOFT facilitators. After the socio-professional study, the training director changed his mind and decided that only the instructors should be the LOFT facilitators. Instructors had more flight hours, participated in more CRM courses, and were more familiar with CRM concepts than checkers. The interviews with checkers indicated that they had a strong technical approach for training (how pilots solve difficult technical problems) and a "checker like behavior" (focus on evaluation of trainees), which is not recommended by LOFT framework. The study also highlighted that checkers were pilots in activity and their job as facilitators would interfere more with the flight schedule and company's costs. The data were also used because CRM and LOFT should be performed annually, and we needed to know whether instructors and checkers, as possible LOFT facilitators, had updated training.

3.1.2 *CRM training observation*

Direct observations of CRM training had two important reasons to be done. The first one was because aviation industry is a highly regulated domain based on global certifications. Certification on CRM can be viewed as a way to harmonize criteria and procedures to ensure liability in techniques and operations management for aviation. Thus, the research crew should be not only familiar and skilled in CRM contents, but also be certified in CRM. The second one is because a CRM training session is embedded in the organizational culture and transmits its contents. This is especially interesting because the training disciplines include consolidated practices and desirable behavioral contents.

CRM training is delivered by the company in two phases, initial CRM and CRM phase II (recycling), addressing the following topics: communication, staff training and maintenance, management of workload, technical proficiency and automation. The CRM phase II, on an annual basis, corresponds to a recycling of the people who did the initial CRM. It is based on the analysis of the final reports of the initial CRM, protocols coming from flight observations, and data collected by the Department Company Flight Safety. Observations were carried out in loco of initial CRM and CRM phase II trainings. There was also the participation in the planning meetings and in the evaluation of these trainings. The purpose of the observations was to identify and register the CRM content, how it was developed, and the performance of trainees in relation to the CRM concepts to support the LOFT standardization.

The observations were made by comparing the company's CRM training program and ICAO guidelines for CRM/LOFT. As the LOFT is the practical application of CRM concepts, to know the company's CRM training and their contents provided the basis for the design of LOFT scenarios.

3.1.3 *Reference situation analysis: emergency training*

The main reason to use emergency training of the company as a reference situation for LOFT design was because these training sessions were conducted in the same simulator that would be used in LOFT and the potential trainees would be the same ones. The total duration of each training session was 5.5 h (1-h briefing, 3.5-h simulator session, and 1-h debriefing). The pilots had to take part in 12 sessions, with 1 session used for check purposes. It was based on an intensive series of emergency exercises and abnormal situations. The researchers observed four complete sessions with two different instructors. The researchers also attended the briefings and debriefings of over five training sessions and checks, with permission of the instructors and checkers. These observations enabled researchers to perceive variabilities during training, as well as strategies of instructors to regulate them. These variabilities were related to behaviors, actions, and training technologies that could compromise the realism of the LOFT being developed, such as:

(a) documentation of the aircraft, crew, and/or flight documentation incomplete or non-existent;
(b) simulator component missing or different from the aircraft in use;
(c) simulator bugs and failures;
(d) variations in the performance of instructors.

Such a long observation period inside the company also allowed the process of immersion into the organization practices, shedding light about the process of piloting an aircraft, and achieving a basic understanding of company (and aviation domain) culture. During the emergency training sessions taken as the reference situation, it was possible to understand how instructors conduct the training, the communications between instructors and trainees, the difficulties of trainees and instructors, the training content, evaluation criteria, etc.

The different performances of the instructors indicated the need to standardize the conduct and management for the LOFT, which would be performed later by facilitators trained for this purpose.

Through observation, it was also possible to identify unwanted situations that would be likely to occur in LOFT. These situations were related to problems with equipment (e.g., simulator reliability), the structure of emergency training (documents, team, resources, schedule, team training), and variations in instructors and trainees (pilots) performance. Thus, the observation of emergency training as a reference situation provided to the researchers and stakeholders a solid basis for the process for the design and standardization of LOFT, contributing to the anticipation of some situations avoiding constraints during LOFT design.

3.2 Focused research: data collection for LOFT design

During global analysis, a mutual recognition about the importance of the workers participation and researchers mediation for situated design was achieved, which is very important for the focused research phase. When fully achieved in a grounded research, this mutual recognition develops in the subjects a will, a desire to talk more and more about their work in the organization. For an ergonomist, however, the conversation is not a casual act, and it is a natural procedure, with specific methods and techniques. This focused research phase was based on conversational action with potential LOFT facilitators of the company. A conversational action requires a set of semi-structured topics (the conversational plan) and analytic listening (Vidal 1994; Vidal et al. 2009). For this purpose, we developed a set of topics for conversational action (de Carvalho et al. 2009) which had been tested and validated by the company experts (counselor–facilitator; human factors coordinator). The aim was to gather information regarding training needs: the content for the LOFT to pilots and facilitators, the training period, the training frequency, the training duration, the types and contents of scenarios and recommendations for elaboration, and the expectation of the pilots and instructors (potential facilitators) about the LOFT implementation in the company.

The conversational actions were conducted with 9 simulator instructors, 4 checkers, 1 route-training instructor, and the training director of the company. At this stage, we were authorized by the training director to address only the instructors, checkers, and the training director himself. Among them, there were instructors, who were retired pilots, and checkers, who were still active pilots of the company. Therefore, the subjects involved had a lot of flight experience as well as in providing training. Flight pilots would only be addressed after running the LOFT as trainees (users), to assess the training. The conversations occurred over a period of 5 months, lasting 45–90 min each. The recording of conversations was not allowed. Alternatively, one researcher used field notes to record parts of the conversations, while the other conducted the interviews.

After the conversations, procedures were used to prepare the raw data for analysis: (1) the preparation of hot reports just after the conversations to organize and enable an immediate reflection on data collected, (2) systematization of the hot reports and their transcription in electronic form, (3) tabulation and classification of speeches, and (4) data analysis.

The results indicated the need to undertake further conversational actions with the same subjects to clarify some issues, as well as with other subjects, like stakeholders (training planning sector, flight engineering department, maintenance, others departments leaders) within the company, and within the Brazilian civil aviation systems as a whole (such as people from air traffic control). We also perceived the need to plan observations of other work-related situations, such as the company's route planning system and the overall flight training system, as well as, to perform a deeper analysis of technical documentation, such as regulatory guides and norms related to the work of a pilot.

After all these new interviews, observations, and detailed analysis of company documents, we were able to conceive the LOFT situated design as an integrated set of company's components including flight and aircraft documentation; facilitators; trainees; technology (simulator and simulator operating system); training coordination; overall training organization and structure (training manual, scenarios menu; training checklist; evaluation forms; facilities, equipment and structure for conducting briefing and debriefing).

It is important to note that these deeper analysis allowed the inclusion of elements of the company's operation, behaviors, and culture. On the other hand, a "non-situated" training design may address situations that are not related to people actual experiences and behaviors and even company's technical and operational issues resulting in a training where people would have more difficult for the assimilation of contents, as they were not related with their actual experience.

3.3 LOFT design

Having completed the comprehensive and the interactional phases of ergonomic action, the project team succeeded in obtaining the conditions for starting the development of the LOFT. The training development was composed by four successive steps: the development of scenarios, the standard operational procedures SOP development, the LOFT test, and the validation of the LOFT.

3.3.1 Scenarios development

The development of the scenarios for LOFT was based on data collected and mentioned in the previous section. Table 2 illustrates the tabulation of some speeches from the instructors, checkers, or training director of the company suggesting different scenarios, comprised by technical failures and managerial problems, supposed to happen in a real flight.

The results indicated that 70 % of flight problems mentioned by the subjects were related to resource management problems and 30 % to equipment failures, which highlight the importance of LOFT for this company. The tabulation of Table 2 resulted in a new array, consisting of the types of technical breakdowns and management problems mentioned by the subjects. Table 3 contains the suggested management problems to compose the LOFT scenarios. The same procedure was done with respect to the types of technical breakdowns suggested by the study subjects.

This information was used to create the set of LOFT scenarios. The management problems mentioned by the subjects were as follows: 33.33 % due to issues with passengers during the flight, 18.75 % due to meteorology, 10.42 % due to conflicts between commercial and technical crews. Regarding technical/equipment failures, the distribution was as follows: About 14.28 % of the failures suggested were related to the hydraulic and the pressurization systems, while 9.52 % were related to the electrical system, landing gear, engine, and the aircraft door.

From the analysis of the set of managerial and technical issues mentioned by the subjects, we identified 12 events (composed by managerial problems and technical failures) that could compose the LOFT scenarios.

The scenarios should be developed for daytime and night flights for 1 hour of simulator time, according to the restriction set by the company's training directorate due to training simulator cost issues, and technical restrictions. Therefore, the LOFT scenarios represent flights from São Paulo (CGH) to Curitiba (CWB), or São Paulo (CGH) to

Table 2 Tabulation of the speeches from instructors, checkers, and training director about potential LOFT scenarios

No.	Instructor (I)/checkers (C)/training director (TD)	Speeches about technical or management issues	Technical (T) or management breakdowns (M)	T	M
Technical and management issues described by instructors and checkers					
10.	TD	The guy takeoff, the airport is suddenly closed, and the landing gear does not rise. Target destination below the minimum. Another airport is open. The company requires him to go there. He has to manage	Plane takeoff and landing gear does not rise (T); airport closed (M); destination below the minimum (M); company requires to go to an alternative destination (M)	**X**	**X**
16.	I16	The scenario should be one to train teamwork. May be a flight from Sao Paulo to Curitiba, around 50 min, 1 h. What we want to see how it is managed. The flight has to be as real as possible. The scenario must include the final readings (navigation, weather destination, the weather of alternative destinations, the aircraft conditions). The destination airport is closed 20 min before arrival. This leads to a team decision-making, which may or may not get stressed. At this time the commissioner enters the cabin to solve a health problem that is occurring with a passenger on board. The commander may be nervous with the decisions to be taken. These flight variabilities will show how crew work as team	Destination airport closes (M); passenger health problem (M)		**X**
		Another situation could be a flight with complicated weather conditions together with complicated weather in alternative destinations, a pregnant passenger sick, air conditioning problems from the takeoff, causing depressurization. Pilots have to know what to do. This implies teamwork	Complicated weather conditions (M); destination airport about to close or closed (M); pregnant passenger sick (M); air conditioning problems (T); depressurization (T)	**X**	**X**

Table 3 Issues related to resource management

N	Man. issues (M)	PAX	ARM PAX	ST	BC	TCx CC	INC	ESC	COM	AT	CONN	MET	AIRP	TTx COOR	OTH
Management issues mentioned by instructors (I), checkers (C), or training director (T)															
1	Pregnant passenger sick. I consult my brief case with the operations general MGO-manual	**X**													
	Transport of prisoners, animals, people armed, bomb complaint		**X**	**XX**	**X**										
2	A flight where passengers ask for much coffee. Com. asks food and do not like the food. Passenger who sat in the wrong place and do not want to leave, overloads the commissioner. Relationship problem among commissioners and passengers causing interpersonal incidents	**X X**				**X**	**X**								**X**
4	(…) Problems of flight routines: passengers changes, changes with flying scale	**X**						**X**							
5	Passenger stroke. Com. looking for doctor on board and he says that flight has to land. The commander will decide where to land. For this decision he will check the weather, consult the company, decide airport, assess the well-being of passengers, evaluates the working time, and the hotel to accommodate everyone	**X**													
Total		15	01	02	01	04	01	01	03	01	01	07	03	01	02

PAX problem related to passenger, *ARM PAX* armed passenger, *ST* special transport, *BC* bomb complaint, *TCxCC* conflict between technical crew and commercial crew, *INC* incidents, *ESC* schedule problem, *COM* problem related to communication, *AT* air traffic problem, *CONN* problem on the flight connection, *MET* problem related to meteorology, *AIRP* problem related to airport operating, *TCxCOORD* problem between technical crew and company coordination, *OTH* others

Guarulhos (GRU), with an estimated flight time of less than 1 h.

Each of the 12 events was analyzed and validated together with instructors, checkers, and experienced pilots of the company. The validation compare the scenario developed with the technical recommendations of ICAO and the scientific literature about the simulation training, taking into account the organizational culture. The aim of this validation was to verify the relevance of these events for the purpose of standardization of LOFT. After that, some of these events have been refuted and others were reworked, resulting in seven general descriptions of LOFT scenarios. Table 4 shows two general descriptions of scenarios.

The development of LOFT scenarios (simulated models of *normal* flights) consisted of detailed descriptions of each flight situation. These scenario scripts were encoded using the technical language of aviation to be fed as data entry for the simulator, so that the operating procedures described in the scenarios could be consistent with flight simulator set-up procedures. The LOFT scenario script was conceived to adequately assist facilitators in their role and to ease communicational interactions with people responsible for external and internal flight resources. Additionally, it aimed to support the facilitators' primary function, which is a real-time careful observation of the behavior and performance of pilots during the training session. This is important because the facilitator plays many roles during the LOFT session, such as air traffic controller, other crew people, control the simulator, and so forth. This process required the participation of a training instructor with experience on the kind of aircraft used to assist in the detailed description of the scenario script and in the simulator setting procedures.

Table 4 General descriptions of scenarios

Events (technical breakdowns; managerial problems)	General description of scenarios
Technical breakdown: landing gear does not go down and the fuel is running out	Scenario 2
Management problem: technical and commercial crew in conflict	Night flight, SAO PAULO (CGH)—CURITIBA (CWB). The aircraft is with minimum fuel for this route. During the cockpit sterile phase, the commissioner enters in the cabin to ask the commander and co-pilot the time they want to eat and the menu of choice. The flight takes place without any problem, and when they trigger the aircraft's landing gear, one of the gears does not go down, and any attempt to solve the problem is successful
Technical breakdown: landing gear does not rise	Scenario 3. V
Management problem: airport closed after takeoff; alternative destination airport has problems due the weather; conflict between the flight crew and the coordination of the company	Day flight, SAO PAULO (CGH)—CURITIBA (CWB). The aircraft takes off and the home airport closes after takeoff. The landing gear cannot be retracted using normal instructions, and failure is such that the procedure does not recommend the emergency retracting. The destination airport has issues with the weather. An alternative airport (Ex.: Campinas) is open. The coordination presses the crew to go to the destination airport. Then, the crew has to manage the situation

The seven scenarios and their respective scripts were described in a document composed by several topics and contents, such as scenario identification; flight number; airport of origin, destination and alternate; scale information; general description of the scenario and scenario script; descriptions about simulator set-up and facilitator role (communications, procedures and injection of events, i.e. managerial problems and technical breakdowns).

3.3.2 Standard operating procedures (SOP) development

Standard operating procedures (SOPs) contain operational and technic procedures to be used as guidelines for facilitators to conduct the LOFT. They are listed in Table 5.

3.3.3 LOFT test

The LOFT test was conducted in the CAE simulator-training facility. CAE is a world provider of training solutions based on simulation technology and conducts the company training. The test was attended by pilots (captain and co-pilot) volunteers, one of the LOFT facilitators under training, and one commander and CRM facilitator. The test was supervised by the company's human factors coordinator and has been observed by the researchers.

The lessons learned allowed new adjustments and provisions for the training, such as adequacy of simulator to the scenarios, reduction in the volume and content of the documents used, change in structure of the analysis sheet training used by the facilitator (supervision through phases of flight, weather forecast control), development of other documents (checklist for conducting training, flight scale), acquisition of aircraft and flight documents, and carrying out corrective maintenance simulator.

3.3.4 LOFT validation

The first 30 LOFT sessions were observed. In these sessions, the seven different scenarios developed were used with participation of three LOFT facilitators accredited by the company, and 60 company pilots were trained. During debriefing of LOFT, parts of the film of each session were presented by the facilitator to the pilots. After the changes indicated in lessons learned, each scenario developed was tested separately with 1 facilitator and 2 pilots in the simulator. During the test, the facilitator's materials (forms and sheets) and LOFT features (e.g., flight plan, general simulator functionalities) were inspected. The purpose of the test was to perform preliminary checks on material and on the simulator, to correct eventual problems, and to prepare the LOFT for final validation. During the final validation, the design of scenarios and the training as a whole were tested again and validated later on with focus groups (checkers and instructors), and monitoring groups (company's CRM and LOFT facilitator, the latter formed during this process).

During the LOFT test, conversational actions took place between researchers and training participants to get feedback from them about possible training problems related to the materials, the structure, and organization, to be eliminated (if possible) or minimized, to ensure realism and the quality of the LOFT final design.

3.4 Development of LOFT facilitator training system

The training program for the company's LOFT facilitators was based on the CRM training platform, following the guidelines of ICAO and the contributions provided by

Table 5 List of SOPs

Technical/operational content	Related documentation	
	Acronyms	Full name
Real flight documentation	METAR	Meteorological advisor report
	TAF	Terminal aerodrome forecast
	NOTAM	Notice to airmen
	Adds-on	Navigation plan, landing/takeoff dates, pilots schedule, and airport documentation
Navigation folder	MEL	Minimum equipment list of the aircraft
	QRH	Quick reference handbook
	ATR	Aircraft technical report
	AOM	Aircraft operational manual
	Adds-on	Logbook, operation manual; track analysis, normal checklist, air charts
Terminal information		Terminal area letters, SID, STAR, and approach

surveyed instructors and checkers. The same resources developed for LOFT pilots training were used for the formation of LOFT facilitators.

The formation of LOFT facilitators proved to be necessary because the company did not have any professional with this training. Thus, the design met a crucial organizational problem, to train people for facilitation roles while preparing the training itself.

4 Results: loft situated design for standardization

The LOFT situated design for standardization encompasses:

- LOFT structure;
- LOFT standard operational procedures (SOPs);
- LOFT scenarios;
- LOFT monitoring system;
- LOFT facilitators training;
- Validation of LOFT.

4.1 LOFT structure

The basic LOFT structure follows the ICAO regulations, and it is similar of a "non-situated" design structure. The LOFT situated design differs from a non-situated one how training materials were conceived, because it took into account the characteristics, capabilities, constraints, culture, norms, values and actual material and human resources of the company.

The aim of LOFT was to allow crews, mediated by facilitators, the opportunity to self-analyze their behavior afforded by flight operation management resources. It was intended that a pair of pilots (captain and co-pilot) would practice LOFT on an annual basis for the estimated duration of 3 hours (1 hour for each phase) distributed in the following phases:

- *Briefing* The first step of the LOFT session, in which a brief revision of CRM concepts, is given by the LOFT facilitator, and the facilitator explains the nature LOFT and training objectives (e.g., clarifying that it is not a pilot check session, describing the roles of individuals in the training, and so forth).
- *LOFT Flight in the simulator* LOFT flight, in which pilots fly in the full scope simulator according to a previously prepared flight scenario. The LOFT facilitator plays the other roles described in the scenario script such as commercial crew, mechanic, ATC controller, and controls the simulator set-up. The aim is to reproduce possible real flight situations. This step is filmed to be used in the debriefing section.
- *Debriefing* Debriefing, in which the pilots, aided by the projection of the filming, exercise self-analysis supported by the LOFT facilitator.

The detailed training structure was designed taking into account the criteria and restrictions set by the company's training director: maximum of 1 h for briefing, 1 h for the LOFT flight in the simulator, and 1 h for debriefing. The LOFT flights in the simulator, from São Paulo (CGH) to Curitiba (CWB), and the transfer from São Paulo (CGH) to Guarulhos (GRU), were defined taking into account already configured airfields in the simulator and the maximum time of 1 h.

The standardization of LOFT was supported by resources and documents:

– Standard operation procedures (SOP) manual;
– Detailed menu of flight scenarios;

- Training analysis sheet (to be used by facilitators);
- Training assessment form (to be used by trainees);
- Procedures data sheet and training checklist (to be used by facilitators);
- Flight documentation;
- Aircraft documentation;
- Simulator issues;
- Briefing, dispatch and debriefing facilities.

4.2 LOFT standard operational procedures (SOP)

The SOPs were standardized through several documents appended to the initial list of Table 5. SOPs were organized in set of documents for the LOFT. All these materials were distributed to participants according to some training criteria differentiating facilitators from the others participants.

Some documentation was distributed before the LOFT session: LOFT scenario folder, including seven flight scenarios with the real flight documentation, Navigation folder Flight documentation was distributed before the LOFT session to both pilots and the facilitator, but the scenarios were available only for facilitators. Complementary documents were available inside the aircraft (simulator) for consultation by the pilots during flight: air charts, terminal area letters, SID, STAR, and approach.

The standardization of SOPs produced types of materials which are to be used in LOFT. They are as follows:

- Analysis of the LOFT sheet to be used by the facilitator during all LOFT steps;
- LOFT evaluation sheet to be used by the trainees at the end of training. This sheet was to be filled in the absence of the facilitator without pilot identification;
- List of management procedures for the facilitator containing the steps and procedures that the facilitator was required to follow, and the steps to be taken while conducting LOFT;
- Checklist for LOFT application to be used by the facilitator. It is a compliance checklist of LOFT elements and its standardization;
- LOFT facilitator folder containing data on candidates for the position of LOFT facilitator, the record of training steps completed, and whether the company certified the individual candidate to be a LOFT facilitator;
- Pilot spreadsheets for LOFT control; document with the requirements for a pilot to conduct a LOFT; the LOFT undertaken by the pilot, date of event, facilitator, and scenario that was used in training.

This final package of contents (LOFT scenarios, complementary documents and specific LOFT sheets) was discussed with the group of facilitators, for achieving its validation.

4.3 LOFT scenarios

The development of each LOFT scenario required single combinations among organizational parameters (context, organizational culture, culture of flight safety, tasks, goals, procedures, working norms, rules, and procedures), technological parameters (type of aircraft, cockpit details, typical resources for piloting, etc.), and personal parameters (personal history, knowledge, competences, individual culture, values). The scenarios were developed through conversational action and tabulation of speeches. Figure 2 shows the scenario 06, one of the seven scenarios developed to be used for LOFT.

Each form comprises the whole description of the scenario, the simulator set-up, the facilitator role, related to flight phases, and the following set of documentation: METAR; TAF; NOTAM; list of Delayed Corrective Action; Navigation; Take-off/Landing Computation; Flight Schedule of pilots; specific operational procedures related to each scenario.

4.4 LOFT monitoring system

To maintain and improve the effectiveness of LOFT, continuous monitoring is an important part of the standardization. The issues monitored are as follows: the structure of the LOFT, training management (applied trainings, applied scenarios, etc.), facilitator and crew performance. Figure 3 illustrates the control of the applied scenarios and trainings.

The monitoring was also based on two documents developed and validated with pilots and facilitators: the LOFT analysis form (used by the facilitator) and the LOFT evaluation sheet (used by trainees). These documents allowed the construction of a dynamic database to perform ongoing analysis of training, making necessary adjustments to continuously improve the training system, and the company flight safety standard.

The LOFT analysis form (Fig. 4) was designed so that the facilitator records the behavior of the pilots during the LOFT, with regard to the practical application of CRM concepts. It is an auxiliary instrument for debriefing, the training phase in which the trainees, aided by training videos, exercise self-analysis and have their behavior and performance reviewed by the instructor. This form also is intended to form the CRM/LOFT database to guide the company's human factors coordination with the points which needed to be deepened and/or reviewed for the CRM refresher courses and the design of new LOFT scenarios. In addition, it contains space for field notes on pilots and crew

PROLOFT

SITUATED STANDARDIZATION PROGRAM OF LOFT TRAINING

SIMULATOR SET-UP	FLIGHT PHASES	FACILITATOR ROLE (Communications / Procedures / Problem Introduction)
▪ During taxi, activate failure in one pressurization channel.	ENG START/ TAXI OUT	**NOTAE**: Be prepared to answer the aircrew about MEL in case the decide to consult the TS (ATA 21 31-1 Automatic Pressurization control channel. Number Installed 2, Number Required for dispatch 1. One channel controller may be inoperative).
▪ When crossing the FL 100, activate the failure of another pressurization channel, which will lead to manual operation of the system.	TAKE-OFF/ CLIMB	**NOTE:** In case the crew consults the TS intending to return, suggest continuing the procedure on manual operation.
▪ Opening of the cargo compartment door causing explosive decompression.	CRUISE	▪ Authorize the **emergency descent to FL 090 and when doing it makes a turn to the right to the right bow direct VOR STN, calling SP control on 132.10 frequency.**
▪ Conditions SBSP: Runway 35L, wind 320/10; visibility 6000 m; clouds SCT; ceiling 1000 ft.; temperature 27º C; QNH 1020.	DES/ APPR	▪ After emergency landing and the leveling of the aircraft the chief stewardess **informs that the pregnant passenger is feeling bad and there is no doctor or health personnel on board.** Authorization of traffic: **authorized via arrival BULI and wait for vectoring for J5 procedure to runway 35 L of SBSP. At DAD block call tower São Paulo 127.15.**
	LAND/TAXI/ ENG SHUT DOWN/PARKING	▪ After contact with the ground, authorize **taxi on lane Mto position 05.**

LAST REVIEW 2014, SEPTEMBER First Version	EQUIPMENT XXXX-YY	ACTUAL REVIEW 2014, SEPTEMBER First Version	LOFT Scenario 06

PROLOFT

SITUATED STANDARDIZATION PROGRAM OF LOFT TRAINING

LOFT SCENARIO – 06

FLIGHT: LF 3011	**ORIGIN**: CGH	**DESTINATION**: CWB	**ALTERNATIVE**: GRU

STOPOVER INFORMATION:

Flight LF 3011, from SBSP to SBCT, lasting 00:50 h, complete aircrew and 50 passengers on board. Once the flight finishes the aircrew stays in CWB where they will spend the night.

DESCRIPTION OF GENERAL SCENARIO:

Day/night flight from SBSP to SBCT. Alternated marginal weather conditions at origin and destination. A pregnant passenger is on board. There is a pressurization situation, which leads to manual operation of the system. In the TOC (Top of Climb), decompression happens. After leveling, the steward informs that the pregnant passenger is not feeling well. There is no doctor or any qualified person on board.

SIMULATOR SET-UP	FLIGHT PHASES	FACILITATOR ROLE (Communications / Procedures / Problem Introduction)
▪ Aircraft in position 05 SBSP. ▪ Runway 35L. ▪ Night/day simulator visual ▪ Flight conditions: wind 320/10; visibility 3000 m; clouds SCT; ceiling 2000 ft; temperature 25º C; QNH 1020. ▪ Fuel: requested by the pilot in command. ▪ ZFW 30268 ▪ MACTOW 28%.	COCKPIT PREPARATION	▪ ATIS via ground control, **Runway in use 35L, wind 320/10, visibility 3000 m, ceiling 2000 ft., temperature 25º C, and altimeter adjustment 1020**. ▪ Traffic authorization: **Authorized according to level 280, via UW24, KING exit, NIBGA transition, initial restriction 5500 ft, transponder 3011, exit control 133.85.** ▪ After door closing the stewardess informs the pilot in command about the 7 month pregnant woman on board (it is necessary a medical note to be presented) ▪ **NOTE:** 1) To observe and follow the use and the sequence of changes of the correct frequencies; 2) Do not forget the signs provided by the stewardess indicating that the cabin was ready for push back and take off.

LAST REVIEW 2014, SEPTEMBER First Version	EQUIPMENT XXXX-YY	ACTUAL REVIEW 2014, SEPTEMBER First Version	LOFT Scenario 06

Fig. 2 LOFT scenario 06

MONTH	FACILITATOR	APPLIED SCENARIOS							APPLIED TRAININGS
		SCN 01	SCN 02	SCN 03	SCN 04	SCN 05	SCN 06	SCN 07	
SEPTEMBER 2014	F1	0	0	0	1	0	0	1	2
	F2	2	0	1	2	0	0	0	5
	F3	0	2	2	1	2	1	0	8
	TOTAL SEPT.	2	2	3	4	2	1	1	15

Fig. 3 Applied scenarios and trainings data

behavior, about CRM development and general comments about the operation of LOFT session and problems occurred (problems in the simulator, lack of materials, external interferences, delays, and so forth).

The LOFT evaluation sheet is designed so that the trainees, anonymously, could express their views on the stages of training (briefing, flight debriefing, and LOFT), scenario used, simulator and facilitator, and other comments they deemed necessary.

4.5 LOFT facilitator training

A LOFT facilitator candidate has to be an aircraft instructor of the company, and he/she has to participate in all phases of the LOFT facilitator training program, with 41 h of training:

- Initial CRM training (16 h): basic CRM concepts with participatory exercises about flight resource management issues, allowing facilitators to review these concepts and solve problems according to the CRM approach;
- CRM corporate training (8 h): aimed at exchanging experience among pilots, flight attendants, mechanics, and facilitators through discussions about company's organizational policies;
- LOFT facilitator training: concepts and tools (8 h): LOFT concepts, objectives, and tools. Relationship between LOFT and CRM concepts, use of LOFT tools (LOFT scenario, LOFT analysis sheet). It aimed that LOFT facilitators learned, during their formation, how to proceed in the three steps of LOFT (briefing, flight, and debriefing);
- LOFT facilitator training: oriented training in simulator (9 h): The LOFT facilitator under training conducted 3 LOFT sessions, under the guidance of a certified instructor.

To support the facilitator training, it was developed a set of courseware for the trainees. Eighteen persons took part in initial CRM training, being 10 instructors and 8 checkers. Seven instructors took part in LOFT facilitator training: concepts and tools and seven instructors took part in LOFT facilitator training: oriented training in simulator. Thus, only seven instructors became able to conduct the LOFT of the company, as accredited LOFT facilitators.

4.6 LOFT validation

Researchers observed the first 30 LOFT sessions. In these sessions, the seven different scenarios developed were used with participation of 3 LOFT facilitators accredited by the company, and 60 company pilots were trained. During debriefing of LOFT, parts of the film of each session were presented by the facilitator to the pilots. Then, they discussed each other about the points related to CRM/LOFT skills that were previously highlighted by the facilitator, on the training analysis form. At the end of the LOFT session, the pilots filled out the LOFT evaluation sheet, pointing out their strengths, weaknesses, and necessary adjustments. This whole process and conversational actions with pilots and facilitators allowed researchers to get validation of the trainings and the scenarios and gain insight into the potential of the overall LOFT standardization process, together with information about some adjustments indicated.

The pilots' comments recorded in the LOFT evaluation form, as well as the conversations made during the debriefing and/or, informally, after training, indicated the perception of pilots and facilitators about the LOFT: "Good experience. The LOFT is better than the check as it is a real situation" (Pilot 1); "It is certainly a very good experience" (Pilot 2).

With regard to LOFT scenarios, some comments about experienced real situations indicated that the LOFT scenarios reflect important issues of the company:

"I've had already this breakdown, but the conditions were not like this. You cannot afford to fly with passengers, it is a lot of noise. In the breakdown I had we returned, there were no problems with the coordination of the company" (Pilot 3).

"Problems with passengers happen every day, depending on the passenger type the Company carries. They were spoiled. If there is no candy that we offer early in the flight they ask the Commissioner to get it. If it is a problem and the flight can no longer go to the destination and they have something to urgent do at the destination, they will push

PROLOFT
PROGRAMA DE PADRONIZAÇÃO DO TREINAMENTO LOFT

LOFT TRAINING ANALYSIS FORM

DATE OF LOFT: MONTH ( ) YEAR ( ) TIME OF TRAINING: ________ h at ________ h. IDENTIFICATION OF SCENARIO: LOFT SCENARIO-____/____	DATE OF LAST CRM PERFORMED BY CREW: COMMANDER: YEAR ( ) INITIAL ( ) RECYCLING ( ) CO-PILOT: YEAR ( ) INITIAL ( ) RECYCLING ( )

OBS: 1. The filling of this Form is full responsibility of the Facilitator; 2. The filling of this Form must follow the Manual of LOFT Facilitator.

FLIGHT DOCUMENTATION DELIVERED AT DO	DOCUMENTATION ON THE AIRCRAFT		
☐ Navigation	☐ Items in ACR (Delayed Corrective Action)	☐ AOM – Aircraft Operational Manual	☐ Normal Check-List
☐ METAR / TAF	☐ RTA-Aircradt Technical Report	☐ Flight Logbook	☐ Enroute Charts
☐ NOTAMS	☐ MEL-Minimum Equip. List	☐ MGO-General Operations Manual	☐ Terminal Area Chart, SID, STAR and Approach
☐ Final (Take-off/Landing Data Card)	☐ QRH-Quick Ref Handbook	☐ Runway Analysis (Volum 04)	

PRESENTATION OF FLIGHT CREW

POINTS TO ANALYSE	COMMENT CMTE	COMMENT COP	TIME ON VIDEO	NOTES
ANALYSIS OF FLIGHT DOCUMENTATION				
BRIEFING OF JOURNEY START Concerns specific aspects on the journey, encourages the participation and teamwork and focuses on the concept of error.				
PRE-FLIGHT – TIME OF START RECORDED OF VIDEO: ____:____h				
CABIN PREPARATION				

LAST REVIEW	EQUIPMENT	ACTUAL REVIEW	ANEX 4
SEPTEMBER - 2014 First Version	XXXX-YY	SEPTEMBER - 2014 First Version	FICHA DE ANÁLISE DO TREINAMENTO LOFT

PROLOFT
PROGRAMA DE PADRONIZAÇÃO DO TREINAMENTO LOFT

BRIEFING OF TAKEOFF, DEPARTURE AND POSSIBLE RETURN.				

FASES DO VÔO	SIMBOLOGIA
ENGINE START	ES
TAXI	TX
TAKE-OFF	TO
CLIMB	CLB
CRUISE	CRZ
HOLDING	HLD
DESCENT	DES
APPROACH	APPR
LANDING	LAND
ENGINE SHUT DOWN	ESD
PARKING	PK
GO AROUND	GA

POINT TO ANALYZE

1. COMMUNICATION	2. TEAM FORMATION	3. MANAGEMENT OF WORKLOAD	4. AUTOMATION
1.1 Transmission of information, 1.2 Communicating Decisions, 1.3 Participative Decision, 1.4 Information Search, 1.5 Operational Conflict, 1.6 Assertivity 1.7 Briefings/*Debriefings*.	2.1 Leadership, 2.2 Open *Cockpit*, 2.3 Decision making, 2.4 Dealing with Conflicts.	3.1 Situational Awareness, 3.2 Distractors, 3.3 Priorities, 3.4 Task Distribution, 3.5 Time Management 3.6 Stress and Fatigue.	4.1 FMA reading, 4.2 *Call Outs*, 4.3 Monitoring, 4.4 *Cross-checks*, 4.5 Interference when necessary and at the right time.

PHASES OF FLIGHT	POINTS TO ANALYZE	COMMENT CMTE	COMMENT COP	TIME ON VIDEO	NOTES

LAST REVIEW	EQUIPMENT	ACTUAL REVIEW	ANEX 4
SEPTEMBER - 2014 First Version	XXXX-YY	SEPTEMBER - 2014 First Version	FICHA DE ANÁLISE DO TREINAMENTO LOFT

Fig. 4 LOFT analysis form

you to go all the way to the destination. They said that they know Tom, Mary…" (Pilot 4).

Regarding to the realism of the training, some pilots feel themselves in a real flight:

"As if we are in daily activity…. When we leave (the simulator), we fall into reality and perceive that we was in the simulator" (Pilot 5).

"We do not feel bad for recording the flight, it is important to improve security. We enter, it is a flight" (Pilot 6).

Other pilots have highlighted some differences in the context that prevent the realism in a more comprehensive way. One of them refers to the fact that the actual flight situation does not start in flight preparation briefing as in the LOFT, and there is a whole anticipation, from the moment that the pilot receives the scale that determines next weeks of work, according to the following statements:

"We are operating in a route. If I fly another route, I will study the frequencies at home instead of study everything at moment of the flight" (Pilot 7).

"The scenario is different. At home, when I drink coffee I'm already looking the weather, I'm creating my scenario" (Pilot 8).

The breaking of the realism of the training, due simulator problems, was commented by some pilots, which include: "it could be working 100 % to be more real" (Pilot 9). In these situations, there is a recommendation for the trainees to assume, wherever possible, the simulator failure as a failure of the aircraft, using MEL—minimum equipment list, like in a flight real. It is up to the facilitator to assess whether the failure compromises the development of the scenario, i.e. the LOFT flight, and so interrupt the session or, if not, proceeds normally.

Finally, it is important to emphasize the importance of self-confrontation and cross-self-confrontation methods, used in debriefing aided by the projection of flight film and the field notes on the LOFT analysis form. It enables self-analysis and a new perception the pilots about their work and their performances. The comments of the pilots and facilitators in debriefings, after watch the training video, confirm its importance:

"People think that behave in one way and when you see the film it is not the way you thought you behave" (Pilot 10).

"… I did not realize how much we both move in the cabin. We do not stop" (Pilot 11).

"… It is very important to do self-assessment from the video. Decision making is very fast; You do not remember most of what you did. It is important to look it after…" (Pilot 12).

"I could have done something else. It shows that the problem has several solutions. I was thinking of something else and you came out with a good decision. Correct. This has happened in the LOFT. We expect a solution and unexpected happens, we think: how I don't think about that" (Facilitator 1).

5 Discussion

The first challenge of this research was to restore the relevance of grounded descriptions through ergonomics theory and methods. The situated design framework came from ergonomic work analysis (EWA) approaches that were used when an organization asked for the design of something that was not very well specified and the demands just partially recognized by the people involved. The EWA, based on current work activities, is pertinent to such context because it allows, together with the organization and their workers, a merge between technical modeling and social construction. Technical modeling summarizes the essentials of the organization's structures, whereas social construction establishes the effective links between designers, workers, and stakeholders.

In this research, the merge among the structures conceived elsewhere by regulatory bodies, such as ICAO or Brazilian regulatory body, and local settings produces gaps, conflicts, in which some new settings emerge. The adequate management of those issues was essential for the success of the situated design process, involving the design of scenarios, training tools, procedures, structures, organization, LOFT flight documents, operations, and further training management contents.

A second challenge was to work within a frame for situated design. Situated design was the core notion that ran through the entire research. It combines social construction and situated standardization to allow a tailored development for a specific site. Situated design claims for descriptions, specially its useful contributions. In the specific case of training design, there are major guidelines to be taken into account. The essential idea of training is to propose new representations and other correlated features that shall produce new behaviors. These propositions target a group of people that belongs to a given community, also called a community of practice. Within an ergonomic point of view, a community of practice suggests socio-technical concepts merging technical and non-technical issues. Hence, to produce an appropriated situated design, one needs to organize useful contributions for harmonize them. In this case, this harmonization means to avoid the deviations that a local culture can produce over the essence indicated by the major training guidelines. In the present case, an excessive influence of checkers in training design could result in an excessive emphasis in technical aspects rather than management issues, more pertinent to CRM guidelines.

The third challenge was that descriptions can explain the nature of option that an expert had done along the development of the design. Descriptions allow the materiality of the implementation setting. Major guidelines are produced in a given context, whereas the implementation setting may not meet substantial analogy with the context where the guidelines are produced. Moreover, guidelines typically express materiality in generic terms. Terms are variables, and variables can assume different values in different contexts. In this paper, we touched this question several times, both in technical/operational issues as in the managerial one. We cannot disregard that the training is based on a simulation, and simulation depends on the limitations of the hardware and the particularities of the software.

Even considering the research limitations regarding a proper statistical validation comparing situated and non-situated design results, based on the issues from these three challenges, the method described as an ethnographic record can be used for other researches in similar situations. Therefore, this research contributes to the design of training systems and about how to implement general recommendations about training in a specific organizational setting in a participatory basis. A LOFT situated design was undertaken based in real work situations (on-the-job training), characterized by a combination of organizational issues (work context, organizational culture, flight safety culture, tasks, goals, requirements, operational standards, rules, and procedures), technology (simulator, aircraft), and personal traits (skills, culture, individual values).

Therefore, the uniqueness of each culture, as pointed out by Helmreich and Foushee (2010), and flying context emphasizes the importance of the situated character for the construction of scenarios. The issues listed in Table 3 to compose the LOFT scenarios for this organization may not appear in other companies, because they are not considered relevant for them, or are not part of their reality in some period of time.

The scenarios developed included management problems and technical breakdowns, allowing the practice of CRM skills provided by ICAO and by CAA, and local experiences in the light of knowledge of subjects directly involved in the daily company routine. As shown in Table 3, the majority of scenarios were about conflict between crew and passengers (15), meteorology (7), and conflict between technical and commercial crews (4). These numbers were rooted in the experience of the subjects in problems that they have to face, which are particular of the company. In another organization, as the type of passenger transported may vary from company to company, from route to route, and from a country to another (passengers themselves also have their own culture), this type of scenario may not be displayed as the most important issue to managed and trained.

Dealing with terrorist threats is an example in which the situated design and its continuous monitoring process may help. This situation implies the adoption of different behaviors by the crew and specific ways of dealing with passengers, running the procedures, and performs communications that must a part of LOFT.

These aspects could have been overlooked if the design of training and its standardization were developed by outside consultants that did not take into account the local, situated issues that are related to the flight problems people have to manage in the company.

6 Conclusion

This paper describes a situated approach for the design, development, standardization, and implementation of LOFT in a major Brazilian airline. It is important to note that the research was based in one case study in a highly regulated domain that remains an exploratory approach, which provides a reflection for future research. To generalize the results, new case studies in the same or similar domains (aviation, nuclear, chemical industries) are needed together with a robust methodology and statistical analyzes would be needed. The situated design was hindered by two fundamental issues: one concerning the task of standardization of training, and the other involving the performance of the training itself (the opportunistic roles of the facilitator and the pilots during LOFT). The grounded approach combines a set of methods and techniques from ergonomics and human factors disciplines. This combination was supported by the social construction, enabling the involvement and participation of different actors of the operational, tactical and strategic level of the company. Situated design was progressively established by socially constructed patterns up to a situated standardization process. In this research, situated standardization appears as the result of a consensus of socially constructed patterns rooted in available technology, procedures, guidelines, and actual work experiences.

The theoretical contribution of the research lies on how to effectively use the situated design, for providing an organizational redesign to accommodate and involve local people and their culture to make a successful training. The focus was on work analysis and participatory design for aviation pilots training enabling a broad understanding of the local problems in the implementation process of LOFT. It is important to note that situated design for the standardization of LOFT enabled the collaboration of several subjects involved in daily routines of flight operations and training in the company. This involvement was decisive to configure a standardization according to the organizational context and trademarks of local culture and experience of the company, expressed by the characteristics of the LOFT scenarios and in the training documentation.

The situated design also produces a debate among specialists in the company because it calls for a permanent exchange of general and specialized knowledge, thus mobilizing the professional competencies available, requiring a social construction. Without such exchanges, situated standardization would not be possible, because only a truly situated procedure could provide the environment to share diverse views and experiences of those involved in the problem at hand. A side effect of the situated design is to put together experts and novices, and people with different backgrounds (pilots, checkers, ergonomists, psychologists, managers), people who do not interact in their normal daily routines. In the sense of Vigostskian's proximal development zone (Wertsch 1988), these new interactions lead to a new shared space for learning, helping in the development of people competences and skills. These perspectives have to be explored further in new research settings. The situated approach also made possible to learn about the dynamic of flight management through an interactive process—shared and cooperative—initially between the pilot and copilot, and then among them and other participants of flight operations, such as crew members, mechanics, followers, whose roles were undertaken by the facilitator during training.

The situated design process created a permanent exchange of knowledge and competencies, mainly during the design phase (LOFT planning and designing), a moment in which these exchanges more often took place. The importance of this interactivity cannot be underestimated, and its absence would imply serious problems in the outcome of the training process. The contributions of the various subjects involved in the pilot training of the company helped us to understand the complexity of the training design, implementation and execution, to gather the data (inputs) and feedbacks arising from various sectors of the company, to negotiate the criteria and constraints coming from people, technology and organizational issues, and involve and engage all throughout the entire process to ensure success of the design.

In terms of social construction, the participatory approach contributed to overcoming existing internal barriers within the company, as it became momentarily open to incorporate external contributions. Moreover, this approach overlaps the purely multidisciplinary structure. Consequently, it integrates several points of view, along with qualified technical contributions, required for the effectiveness of a training process with LOFT characteristics. Hence, the success of LOFT implementation and standardization could be understood as a natural outcome of the situated design process, in turn, a consequence of the establishment of a robust social construction.

Conclusively, LOFT situated design framed by social construction can be applied to any aviation system with a culture and an organization, which may be different from the ones that were implicitly or explicitly taken into account during the development of general LOFT guidelines. A non-situated or *normative* training design implies in a standardization approach based on direct translations of international documents are restricted to abstract training requirements. It does not consider the work context for which the activity of standardization is intended and whose positive changes require robust social constructions. Normative standardization ignores significant particularities of the activity (actual work), thereby losing its primary function as a guide for workers to use trained standard operating procedures required to carry out the activity effectively and successfully. This is why we sustain that normative standardization is an abstract construct so far from the dynamics of real work.

Hence, it should be plead that the situated design, as including an important exchange of knowledge, and demanding a collection of different types of competencies that existed (or not) in the company, in a permanent way, constitute a serious alternative to training design, even besides the present grounded application. Situated design and its participatory methods, especially the conversational action technique, are effective ways (useful and efficient) to develop complex training standards in aviation and in other safe critical domains. Understanding the dynamics of pilot activities—as well as training activities in simulated flight—undertaken within the organization, provides a basis for better cognitive orientation in terms of better prescriptions (normalization based on real activity and CRM/LOFT) and outputs (content, structure, and teaching of training courses and CRM/LOFT) than traditional normative standardization, forming a new cognitive organizational asset. At the level of pilot activities (real work), this asset enables pilots to develop their skills—through the adoption of new attitudes and behaviors—that will help them deal with situations arising from abnormalities and return to normal flight situations, adequately governing flight resources and improving flight safety.

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